Biogeographic approaches for evaluating ecological condition and efficacy of marine managed areas – the Tortugas region case study.

Christopher Jeffrey (CJ)

National Oceanic and Atmospheric Administration (NOAA)
National Ocean Service (NOS)
National Centers for Coastal Ocean Science (NCCOS)
Center for Coastal Monitoring and Assessment (CCMA)
Biogeography Program

Collaborating Entities

- NCCOS/CCMA/ Biogeography Team (Project Lead)
- National Park Service - Water Resources Division
- NCCOS Center for Habitat and Reef Fish Studies
- National Marines Sanctuaries Program Headquarters
- Florida Keys National Marine Sanctuary
- NOAA Special Project Office - Coastal and Ocean Resource Economics
- NMFS - Southeast Fisheries Science Center
- National Park Service – South Florida-Caribbean Network
- University of Miami - RSMAS
- University of Massachusetts - Amherst Human Dimensions Research Unit

Tropical ecosystems provide important goods & services

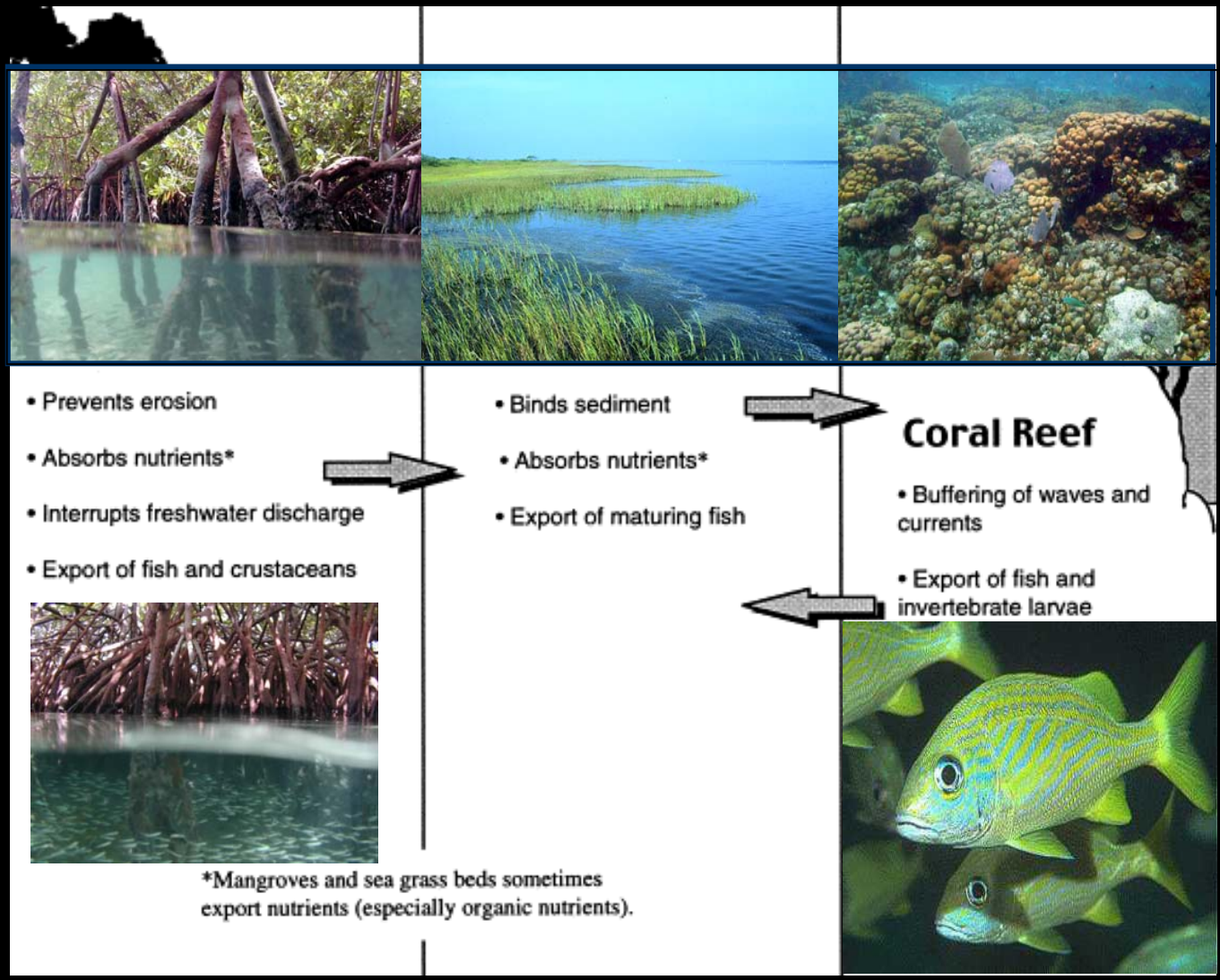
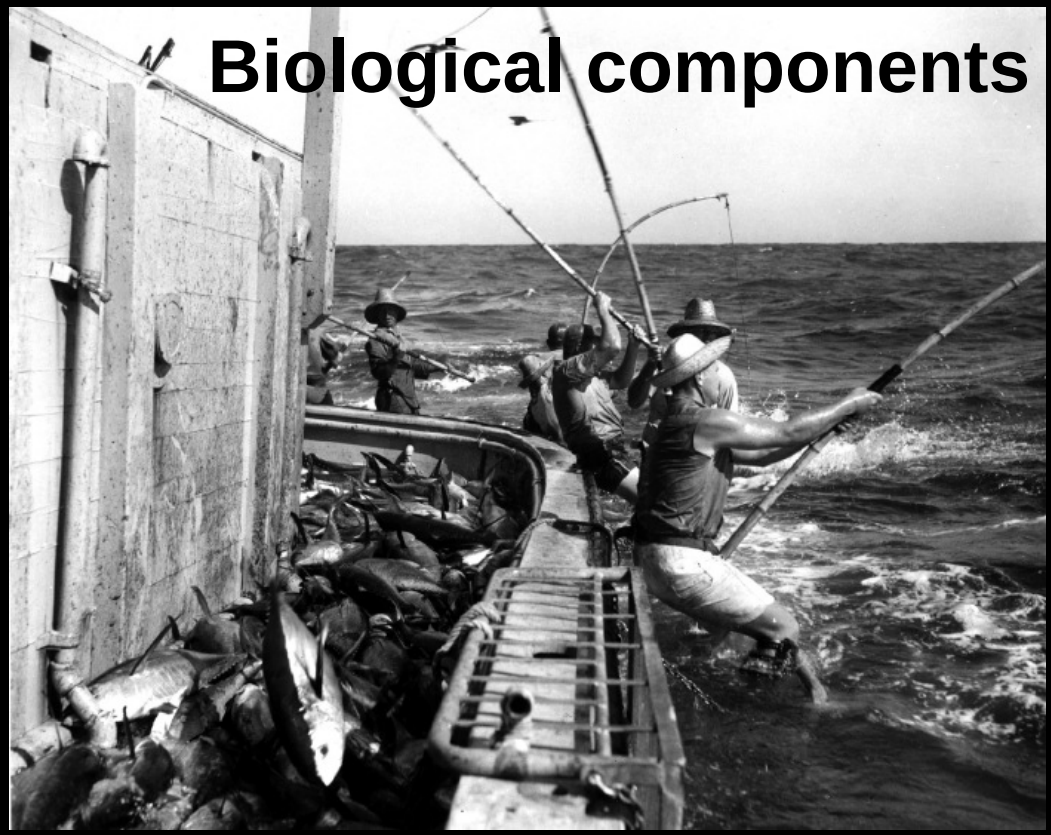


Photo credits: NOAA NCCOS

Adapted from Moberg and Folke (1999)

Biological components are overexploited



Many big fish

What to blame:
overexploitation
habitat degradation

few big fish

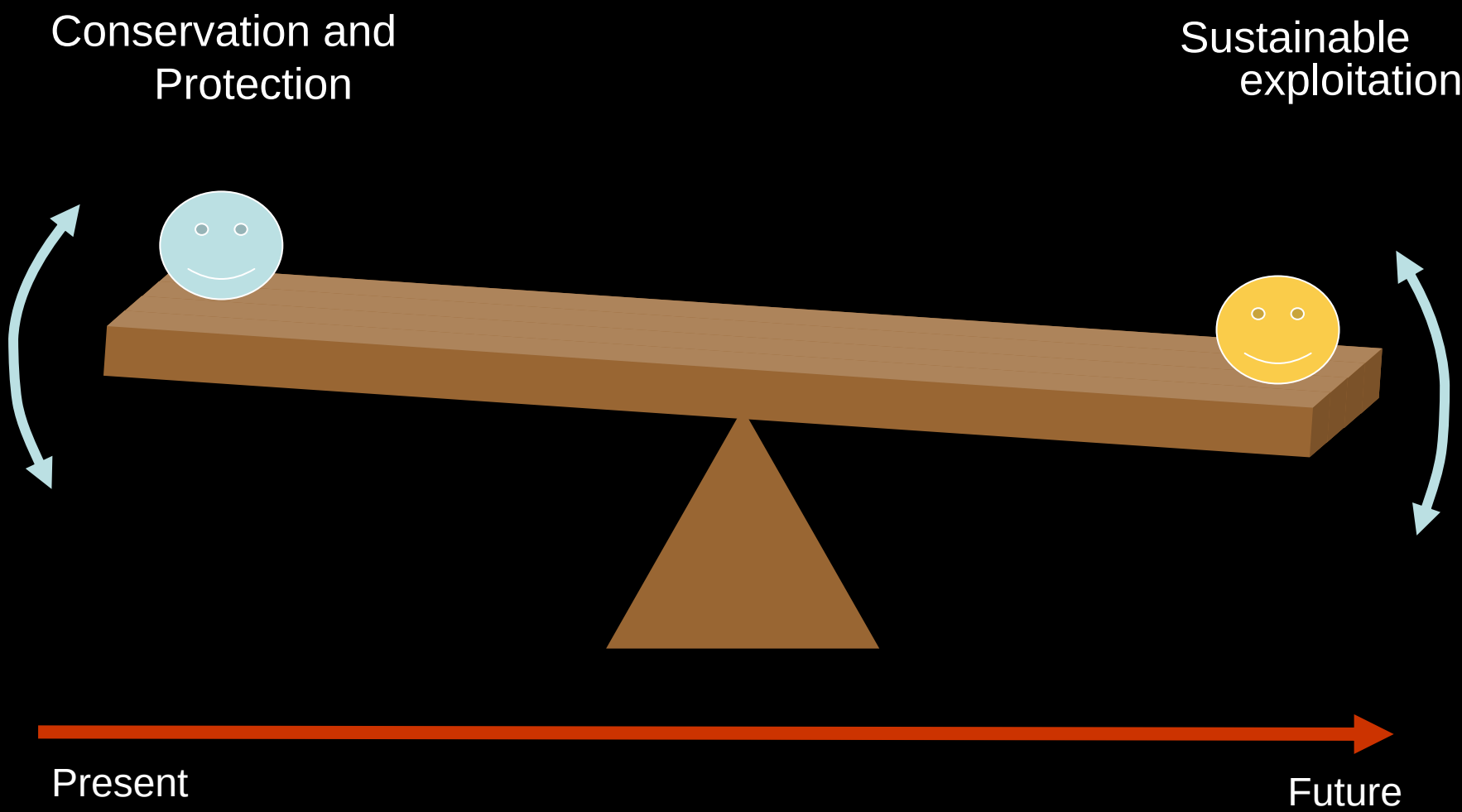
South Florida:

1964-1998:
recreational boats ↑ 444%

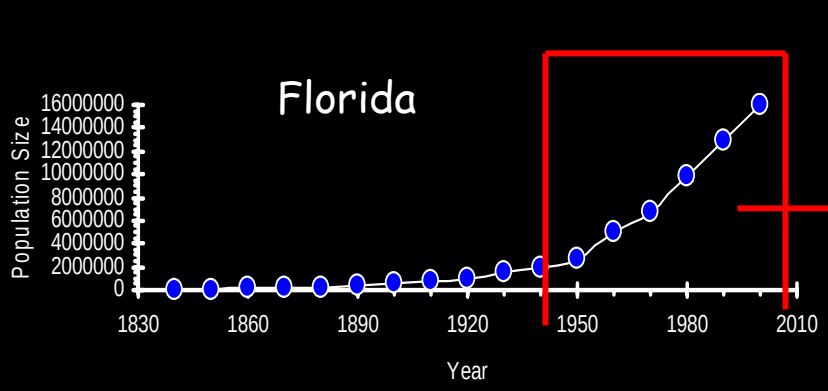
1940-2001:
black grouper ↓ 40% (Ault et al. 2001)

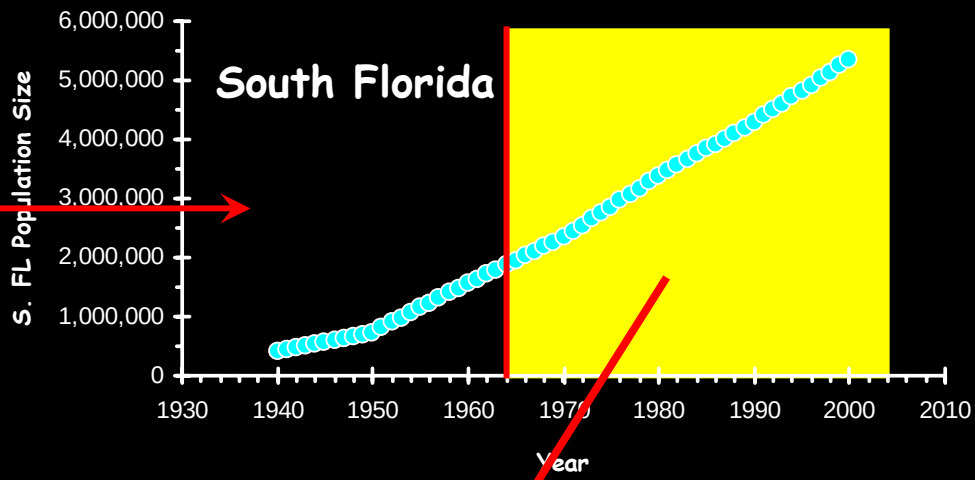
Photo credits: NOAA Photo Library

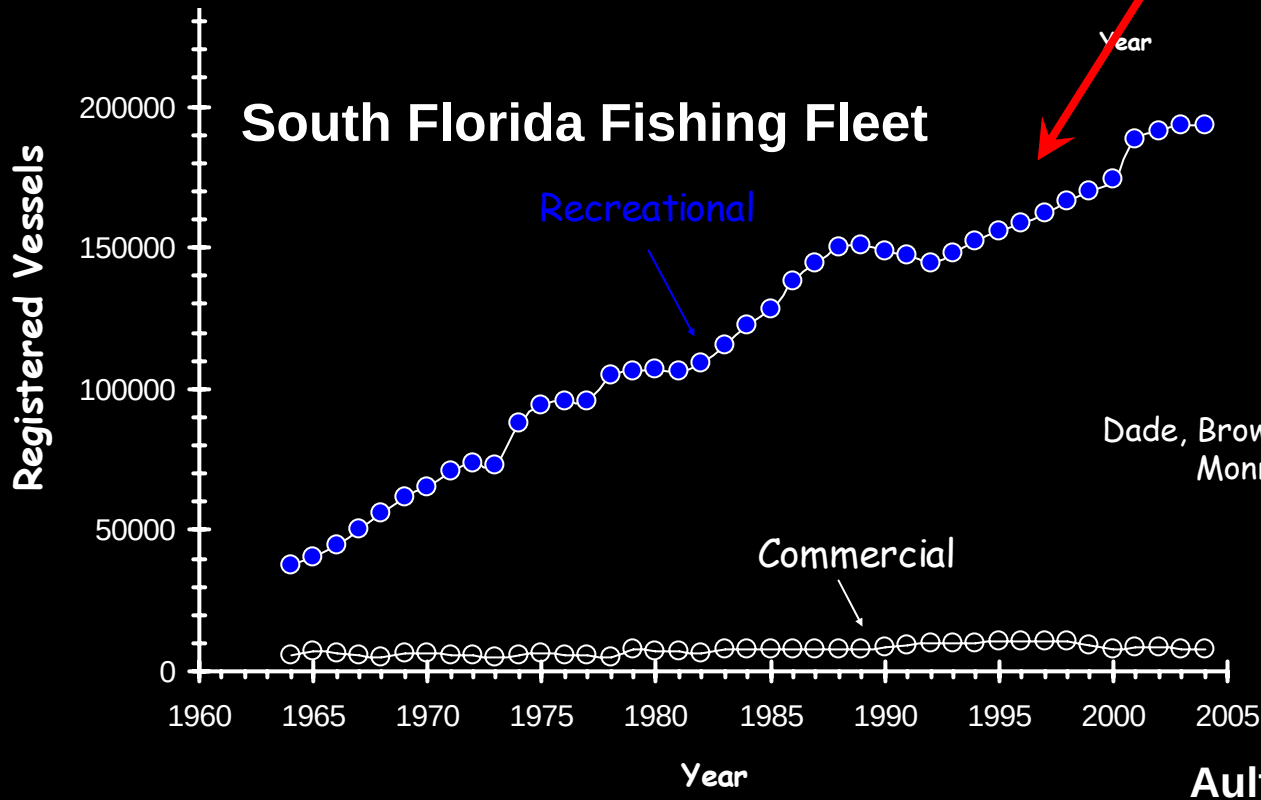
Desired goal of ecosystem management



Florida's Human Population Growth Dynamics

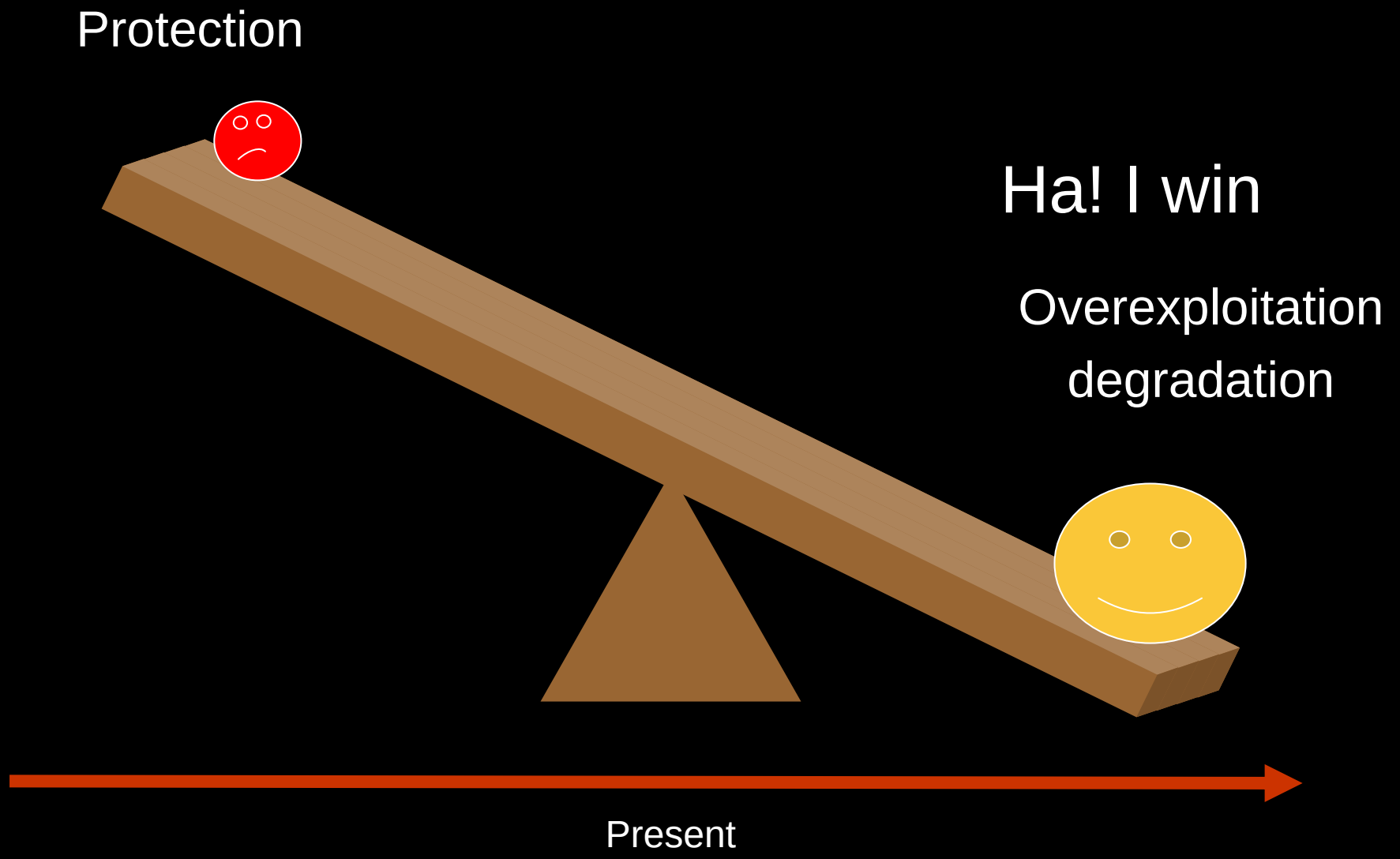




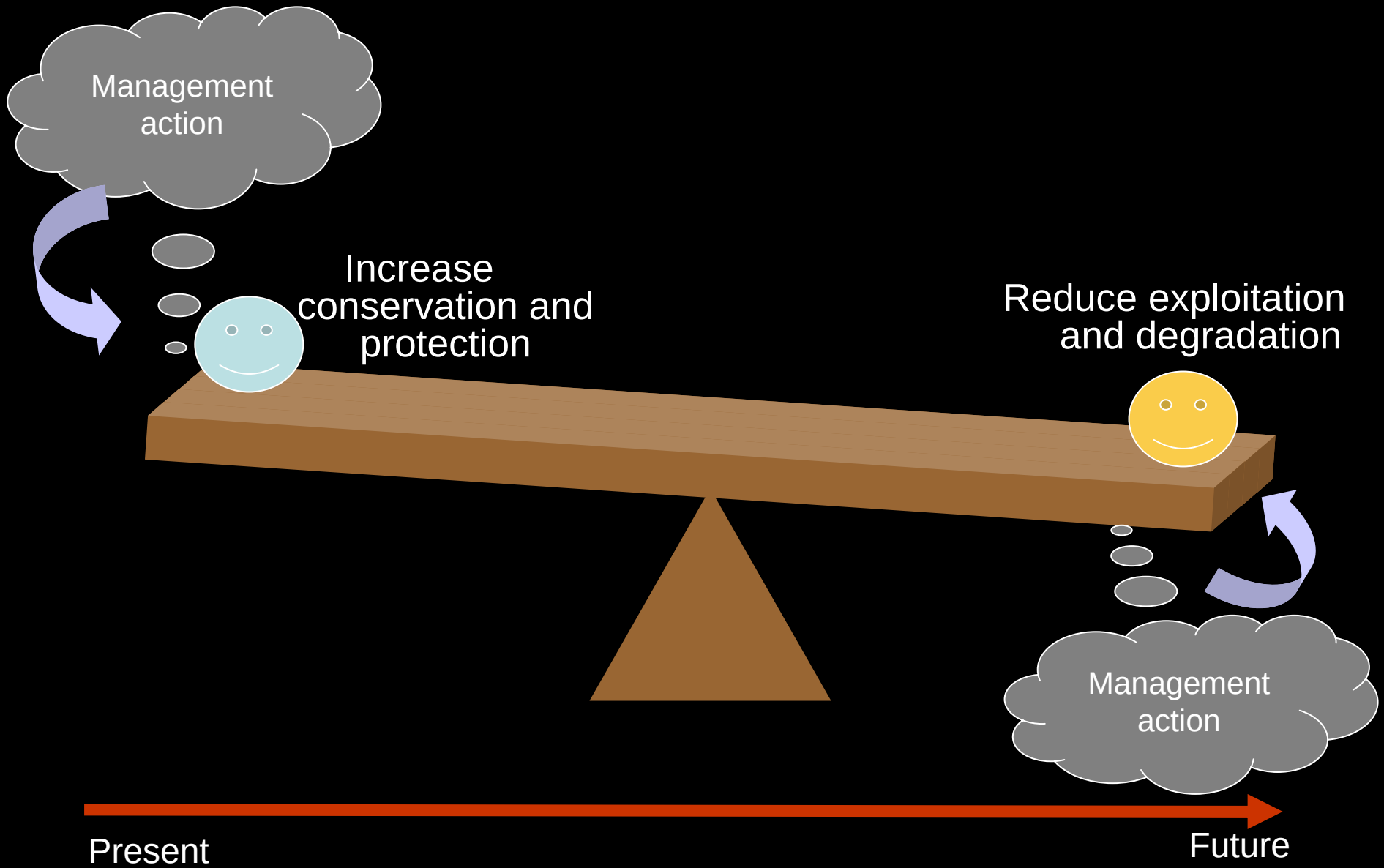


Ault et al., 2007

Traditional management actions may be ineffective for marine resources

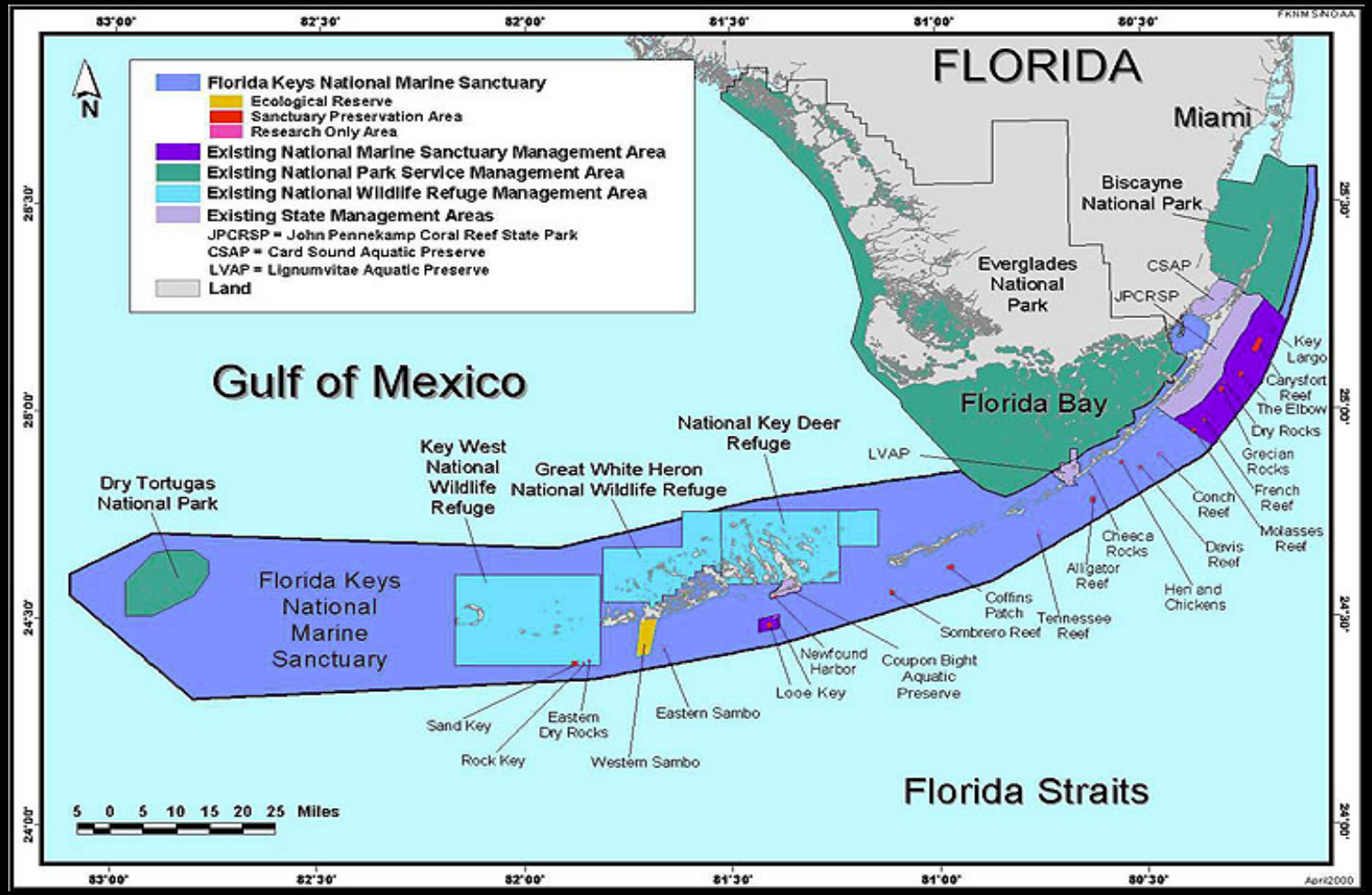


Corrective actions are needed

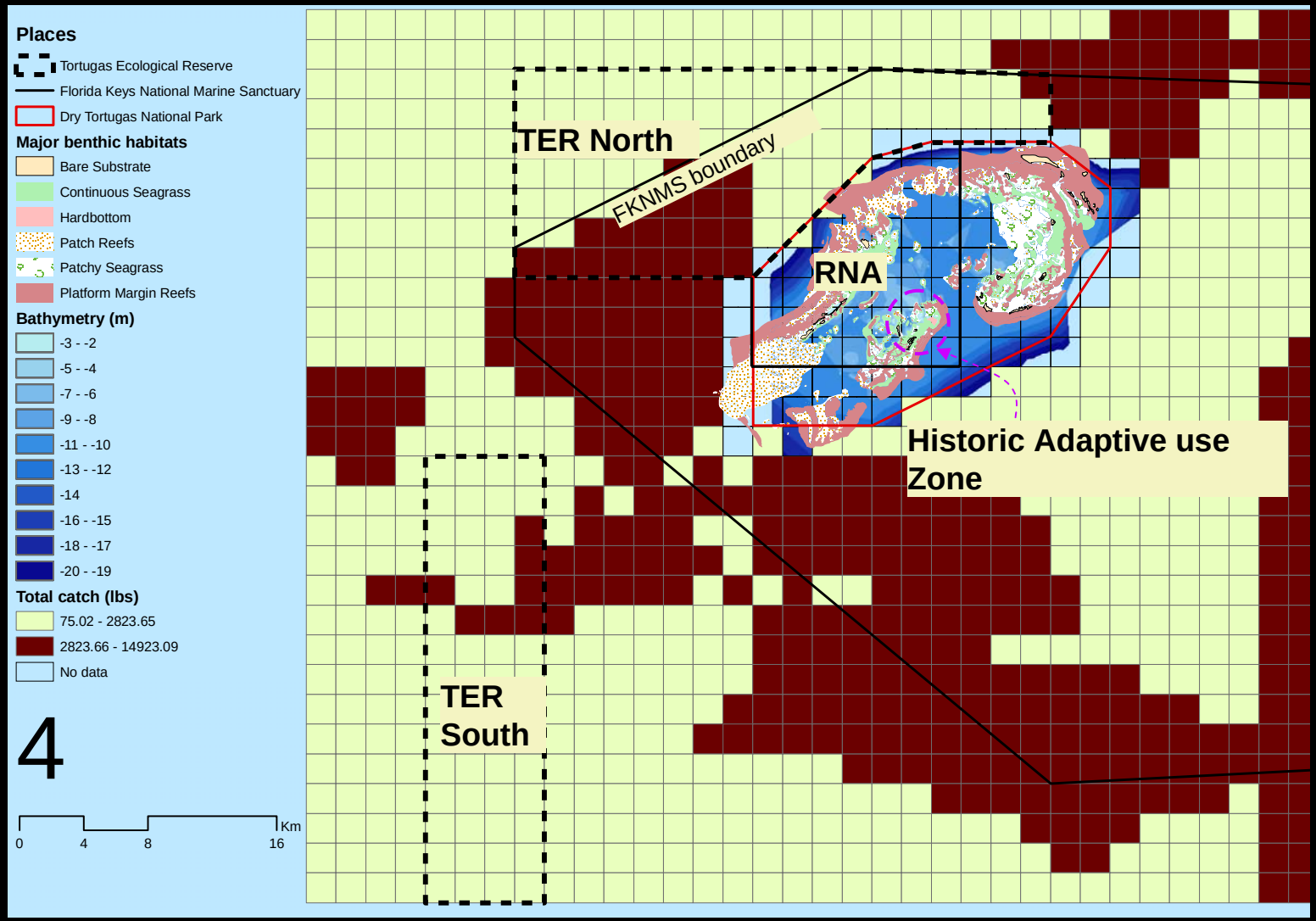


The Florida Keys National Marine Sanctuary

1997: A network of marine protected areas (MPAs)



2000 – Tortugas Ecological Reserve



2005 –DRTO Research Natural Area

Potential benefits of MPAs

- Refugia for exploited populations & critical life stages
- Increased abundance/biomass for exploited organisms
- Export of reproductive propagules from MPAs
- Protection of habitat from physical damage

National Research Council (2001)

Resource management objectives (TER)

Public should:

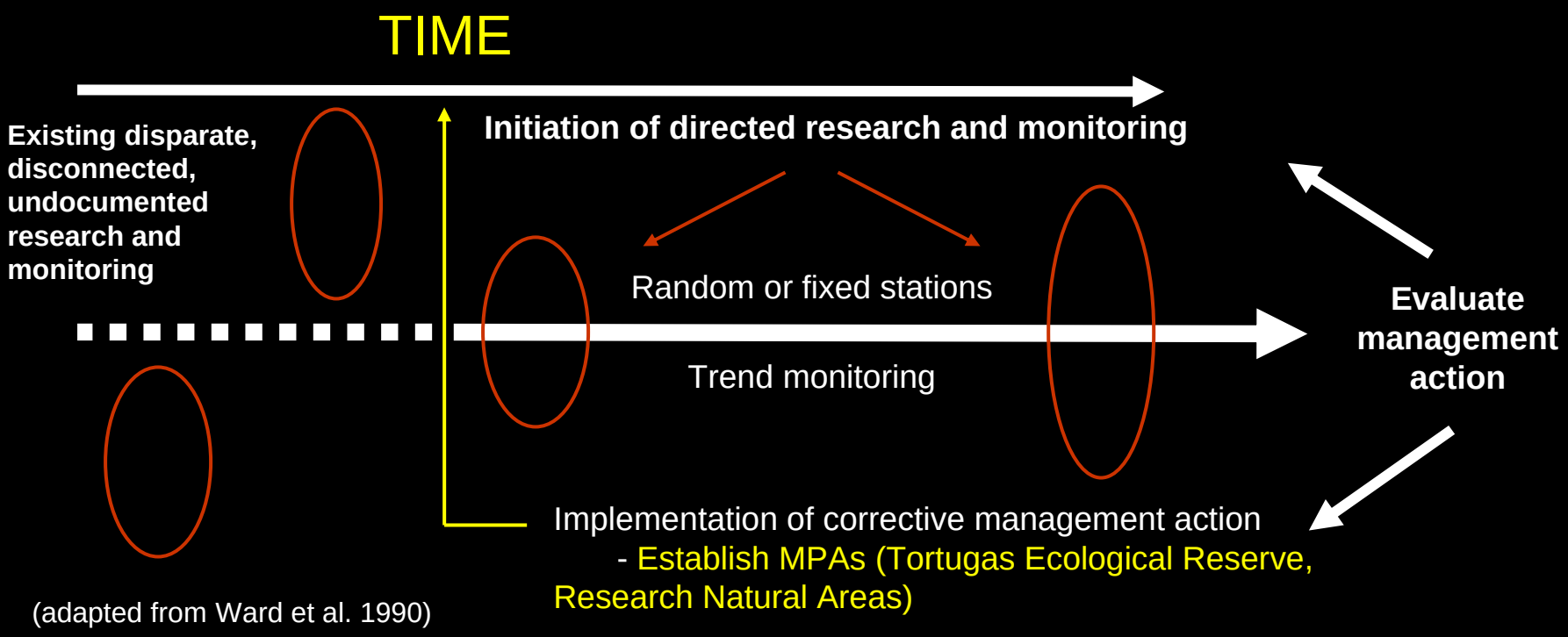
- evaluate sanctuary effectiveness
- distinguish between the effects of human activities and natural variability

Managers must:

- Investigate causal relationships
- Evaluate management actions
- Verify and validate predictive models
- Select appropriate management actions

http://www.fknms.nos.noaa.gov/research_monitoring/welcome.html

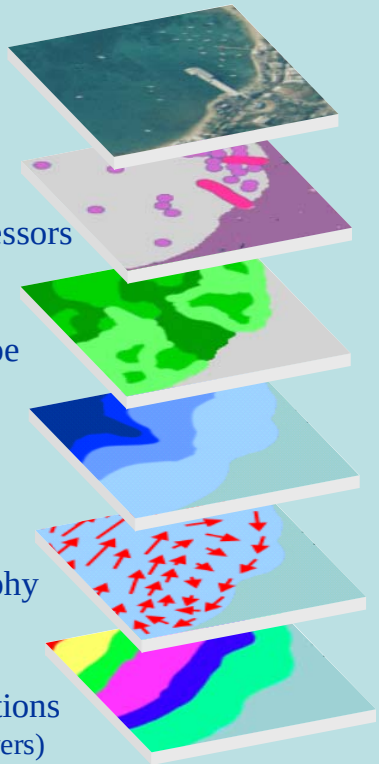
Use targeted research to achieve objectives and evaluate management actions



(adapted from Ward et al. 1990)

Biogeographic Assessment Approach

Individual Biogeographic Data Layers



Imagery

Human Stressors

Bottom Type

Bathymetry

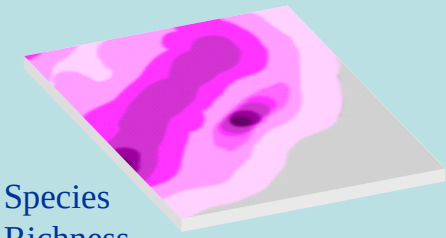
Oceanography

Species Distributions (many layers)

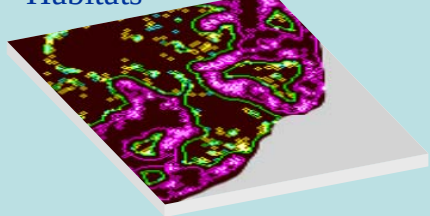
Literature reviews

Combine Biogeographic Layers for Analysis

Example Integrated Biogeographic Analyses*



Species Richness



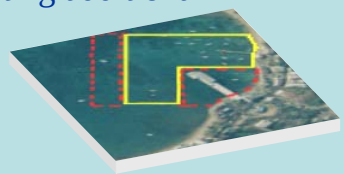
Threatened Habitats

Analytical Products to meet Sanctuary Objectives

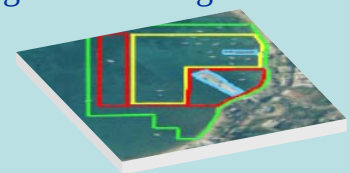
Products to aid in Sanctuary Management

Evaluate current sanctuary boundaries relative to biological resources

Explore options for protecting additional areas



Evaluate Alternative Management Strategies



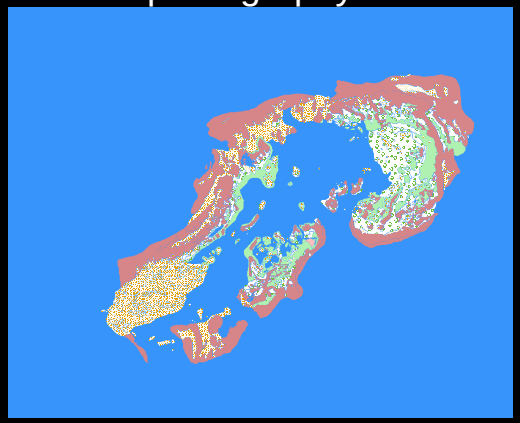
Goals For TER Integrated Assessment

- Conduct a biogeographic integrated assessment of reef fishes (i.e. collect new data and synthesize existing data to):
  - **Characterize reef fish ecology of Tortugas**
    - **Determine a baseline or average condition of the resource**
  - **Determine benefits or impacts of the TER**
    - Biological
    - Socioeconomic and societal benefits or impacts

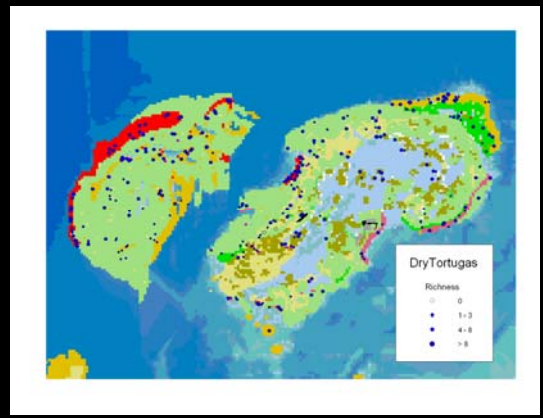
Objective #1 of 4

Synthesize the best possible benthic and bathymetry maps for the TER

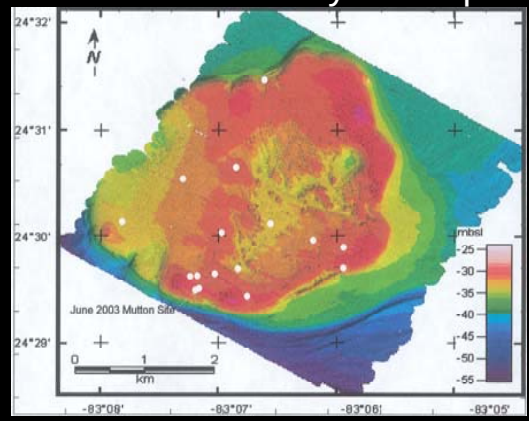
NOAA-FWRI 1998
Aerial photography

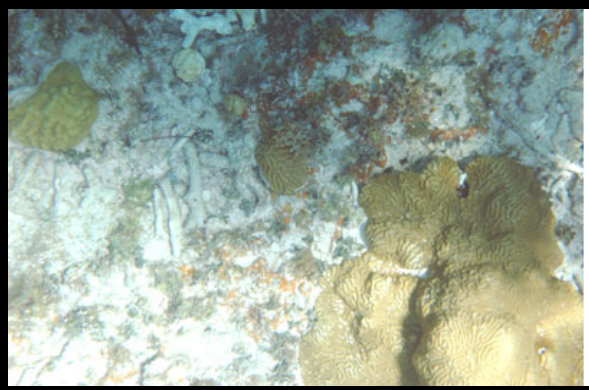


UM-RSMAS: Side scan sonar

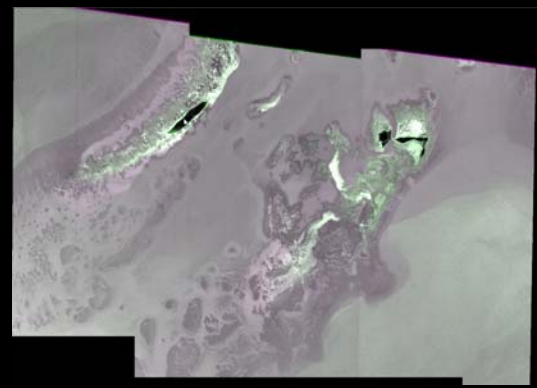


Beaufort:
Multi-beam for Riley's Hump





NPS-USGS LIDAR imagery



Satellite imagery

Managed Areas

- FKNMS Boundary
- Tortugas Ecological Reserve North
- Tortugas Ecological Reserve South
- DRTO NP Boundary

FWRI-NOAA Benthic Polygons

UM-RSMAS 200 x 200m Benthic Grid

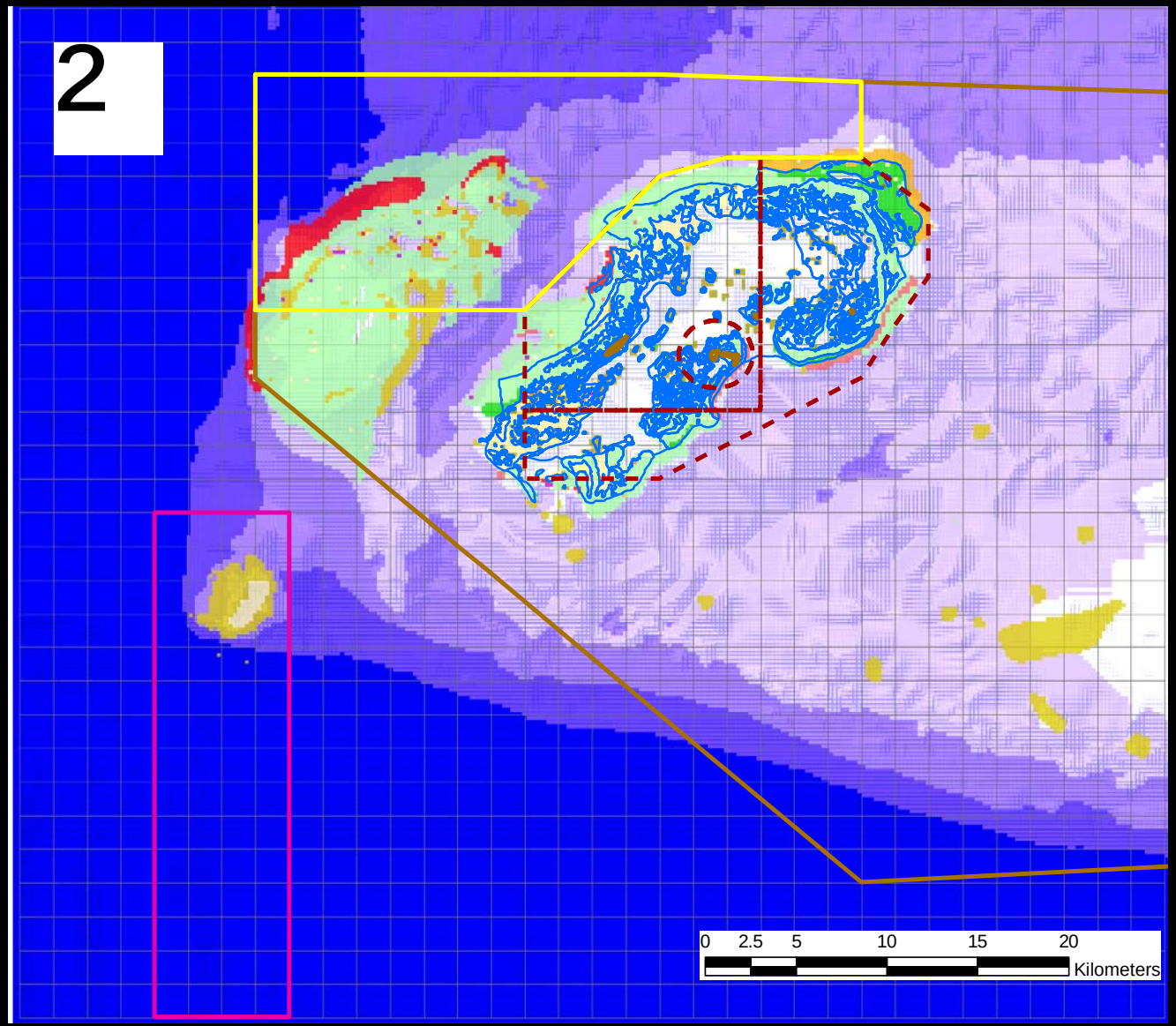
- Low-relief HB
- Low-relief SG
- Patchy HB in sand
- High-relief SG
- Pinnacle reef
- Reef terrace
- Medium reef
- Rocky outcrops
- Patch reef

Depth (m)

- 1- 19.9
- 20 -29.9
- 30 - 39.9
- 40 - 49.9
- 50 - 625

Tortugas 2000 Socio Econ Study Area

UM-RSMAS / NURC Habitat	Area (ha)
Low-relief HB	19,994.94
Low-relief SG	1,183.73
Patchy HB in sand	3,752.89
High-relief SG	508.16
Pinnacle reef	68.02
Reef terrace	1,648.02
Medium reef	775.63
Rocky outcrops	4,816.43
Patch reef	2,812.60
Total	**35,560.43**
FMRI-NOAA Habitat	
Hardbottom with seagrass	15.7
Patch reef	868.2
Platform margin reef	9,148.9
Total	**10,032.9**

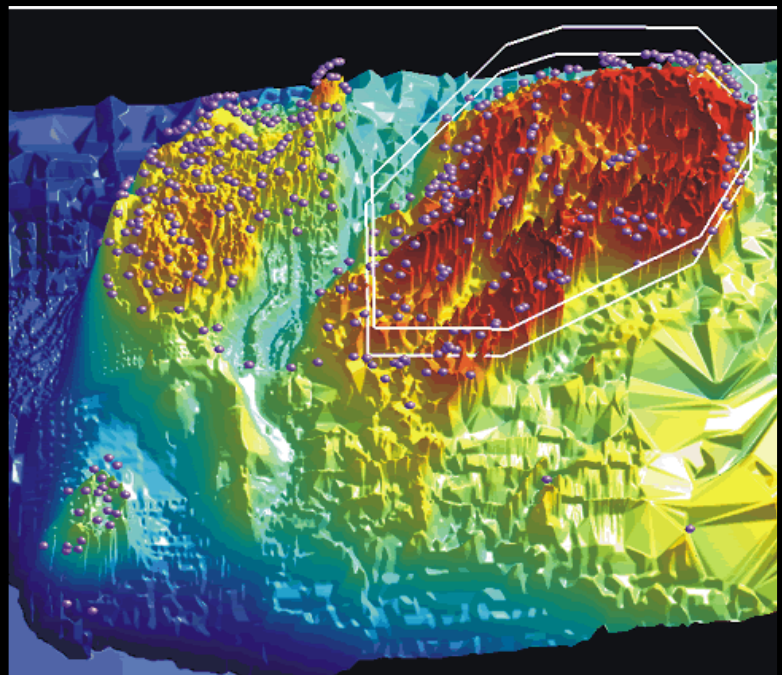


Comparison of hard-bottom areas in the Tortugas region that was mapped by FWRI-NOAA in 1998 and by UM-RSMAS in 2006.

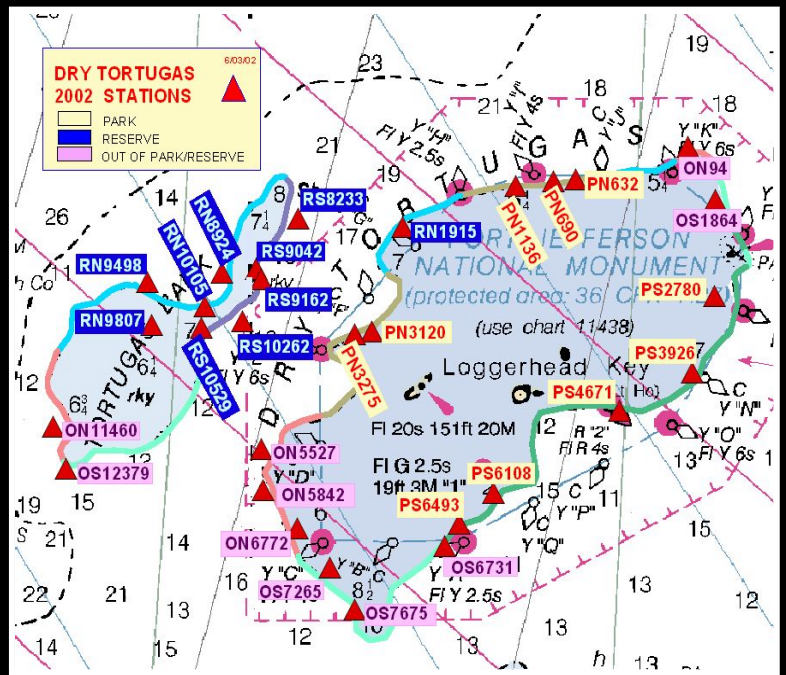
Objective #2 of 4

- **Synthesize and integrate data on fishes**
  - Describe fish-habitat interactions
  - Identify environmental covariates for use in comparative analyses (inside vs. outside the TER)
  - Describe ecological characterization of the Tortugas region;

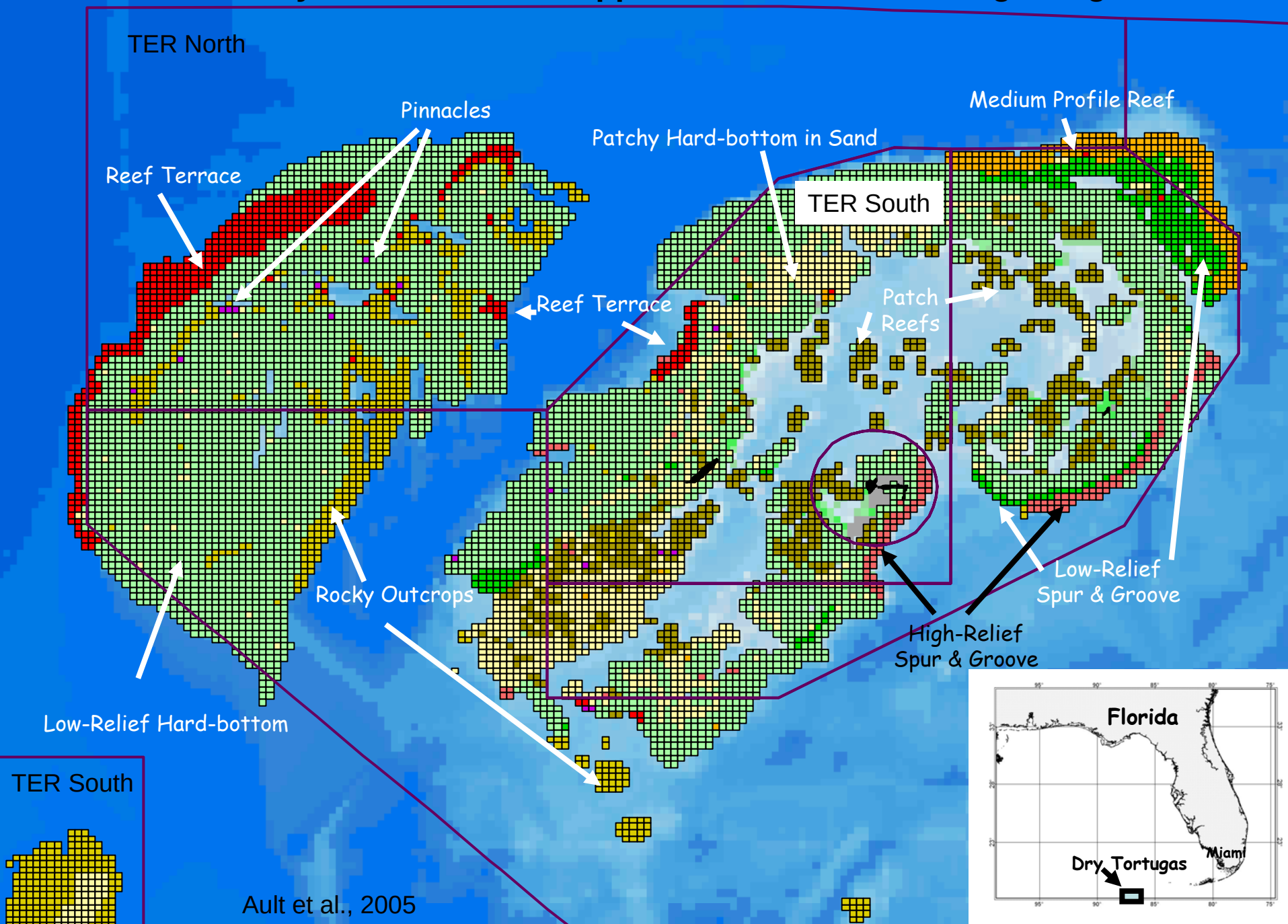
UM-RSMAS 2004: > 3000 random sites
Longer time series (1979 to present)



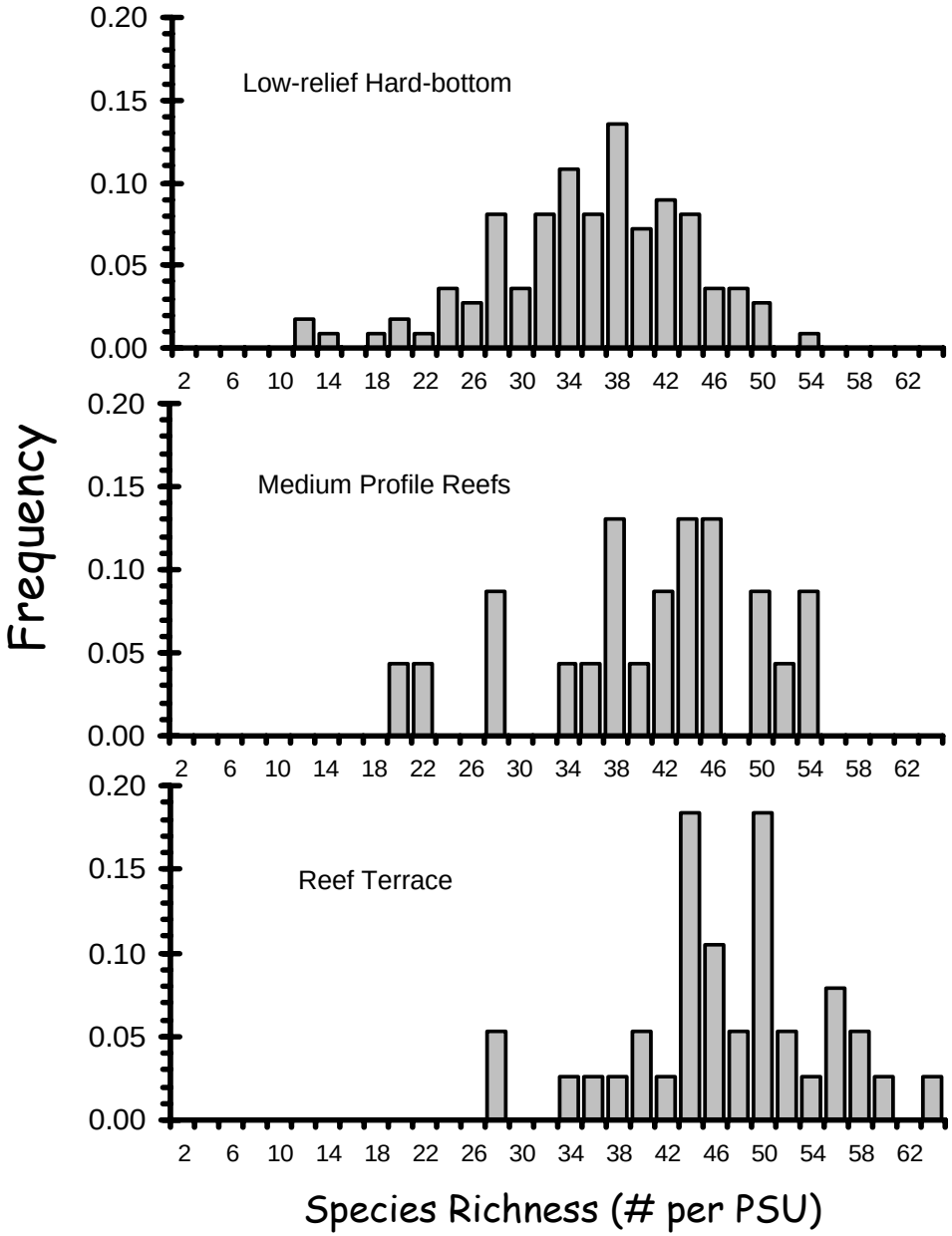
NCCOS CCFHR: 30 permanent stations
Shorter time series: (2000 to present)



Patchy distribution of mapped habitats in the Tortugas region



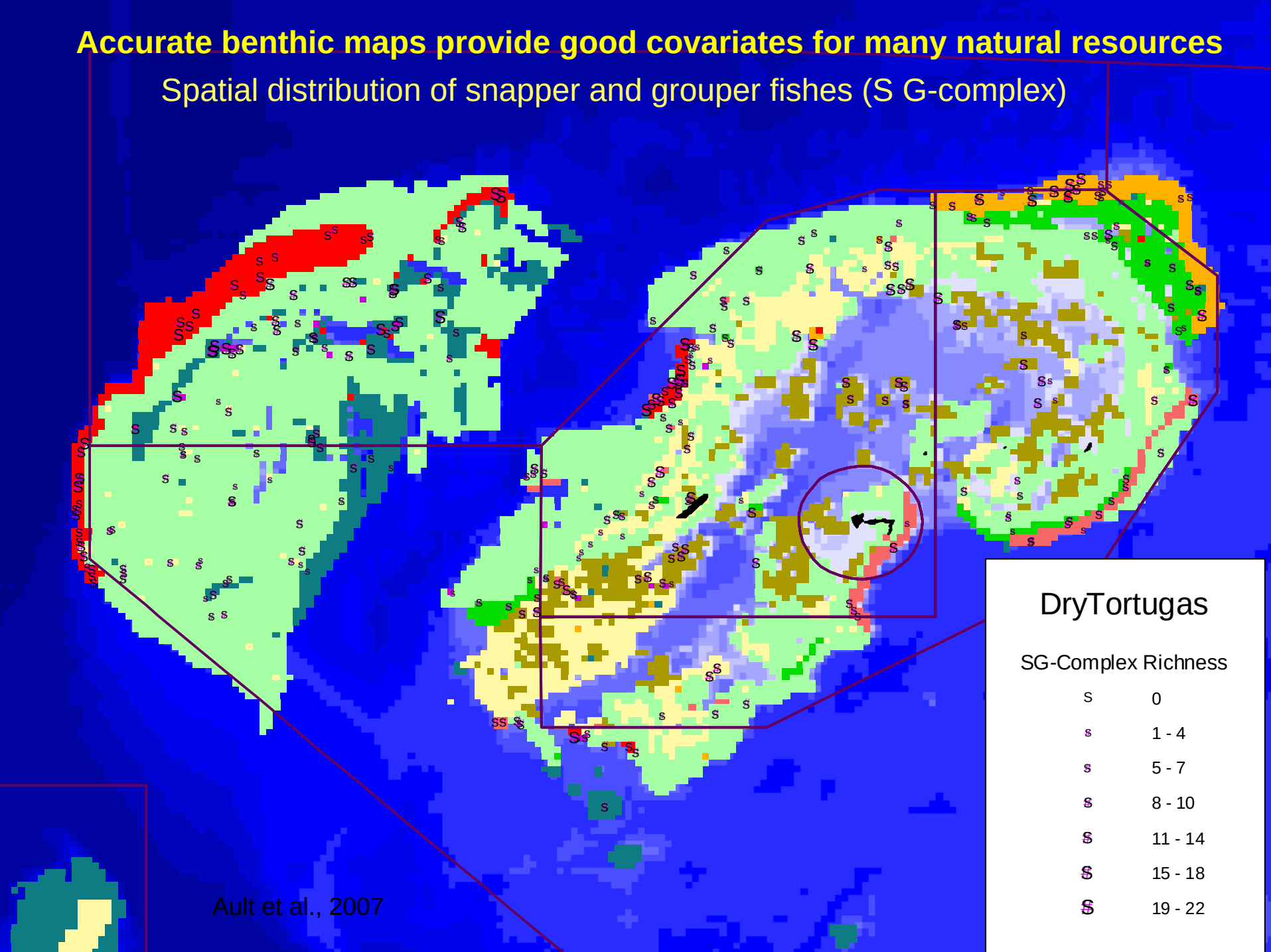
Ault et al., 2005



Ault et al., 2007

Accurate benthic maps provide good covariates for many natural resources

Spatial distribution of snapper and grouper fishes (S G-complex)

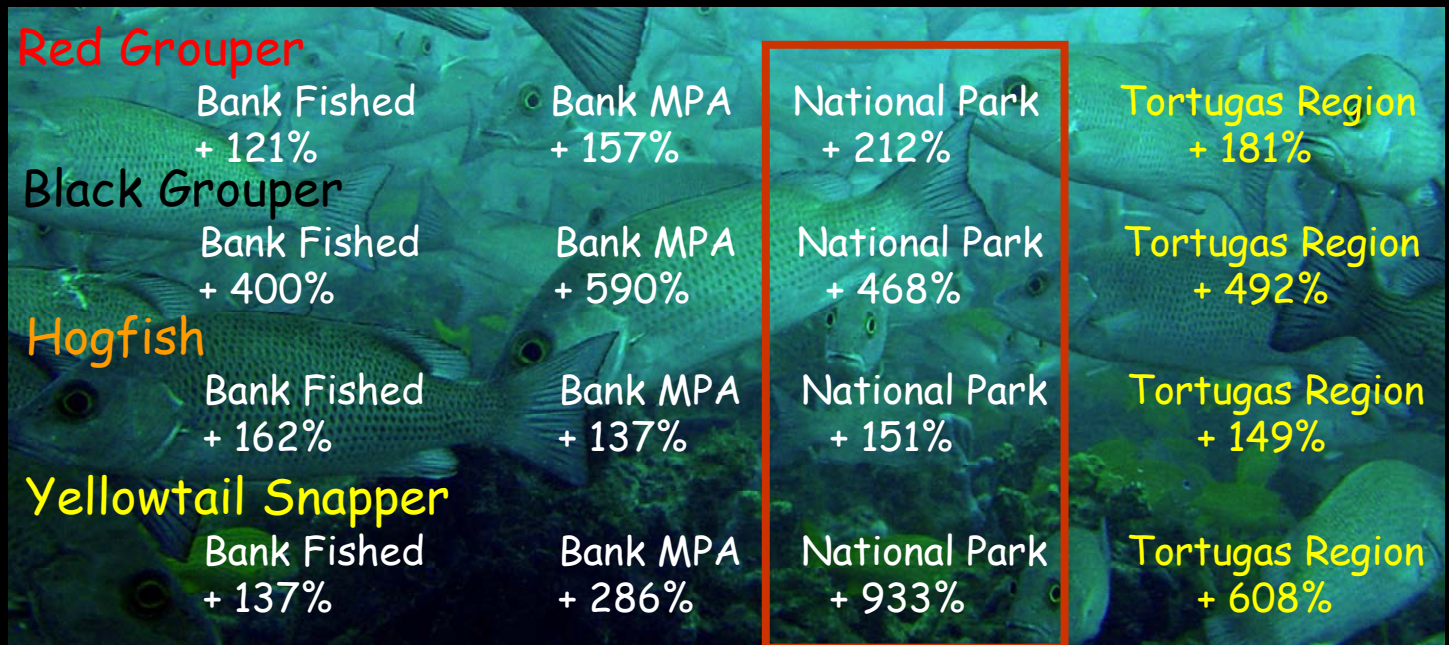


Ault et al., 2007

Objective #3 of 4

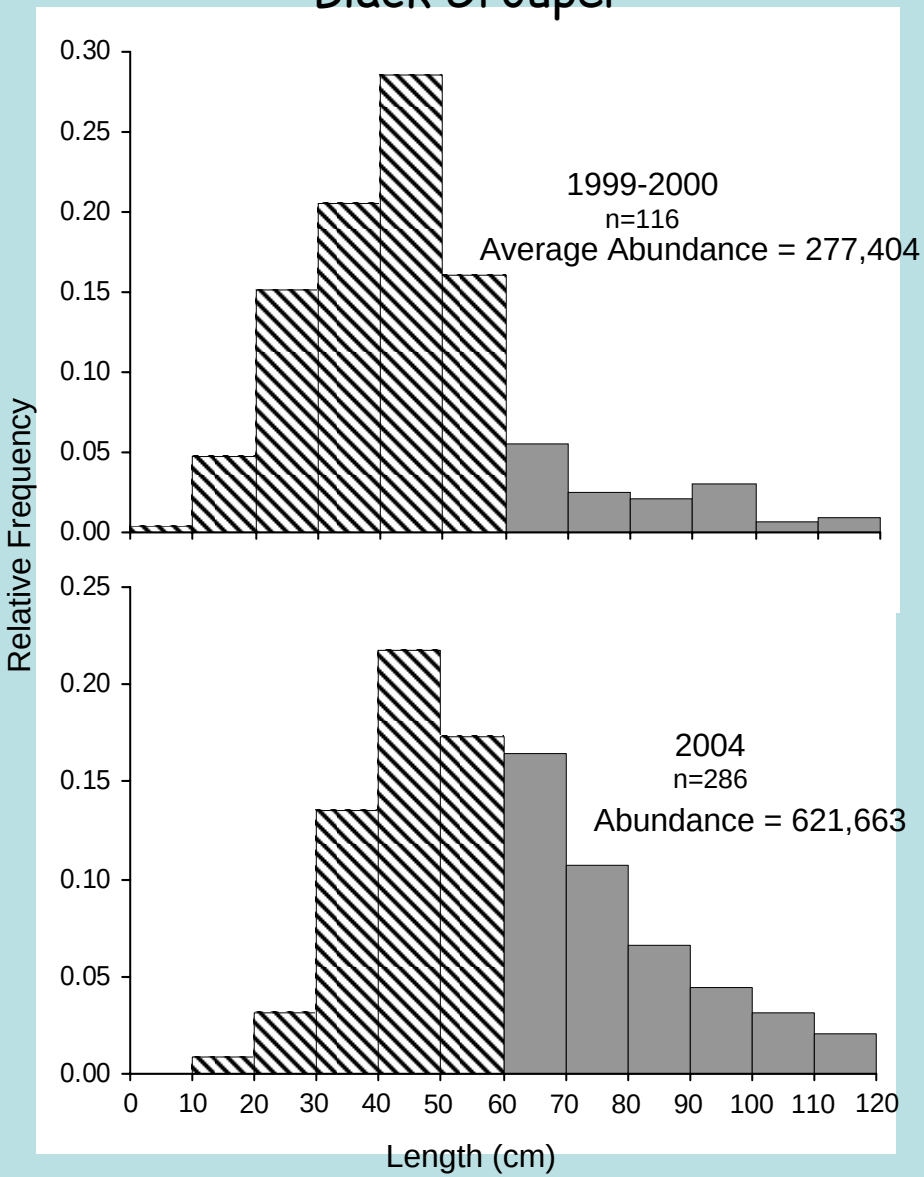
- Develop Spatial Ecological Assessment Models
  - Describe biological responses of ecosystem components following implementation of the TER.
  - Are fish more abundant inside than outside?
  - Spillover benefits?

Observed increase in abundance of exploited species, 2000 - 2004

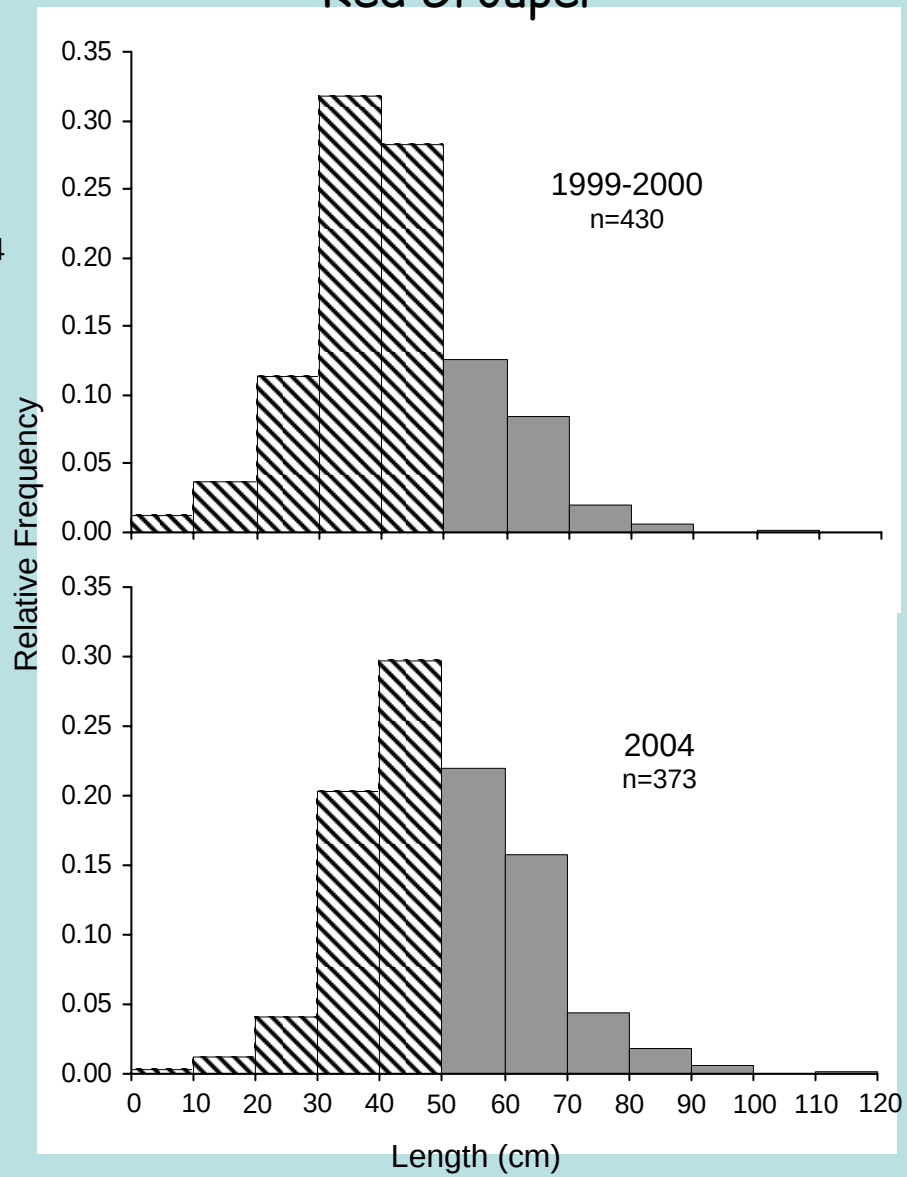


Ault et al., 2006

Black Grouper



Red Grouper

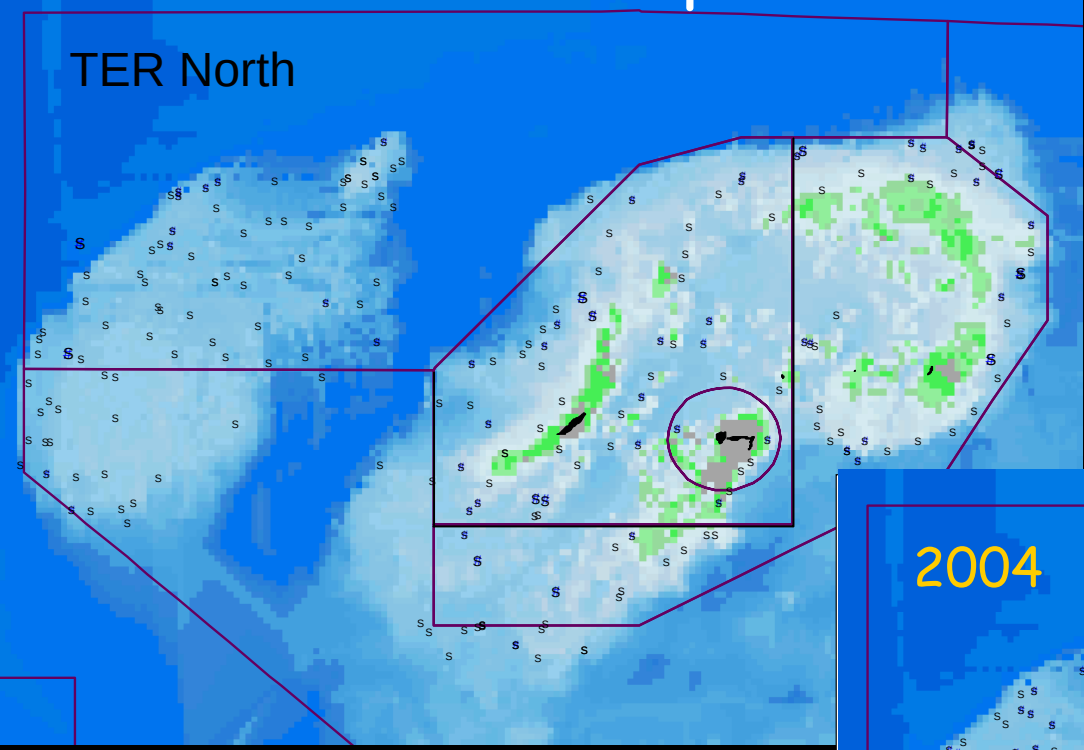


Ault et al., 2007

2000

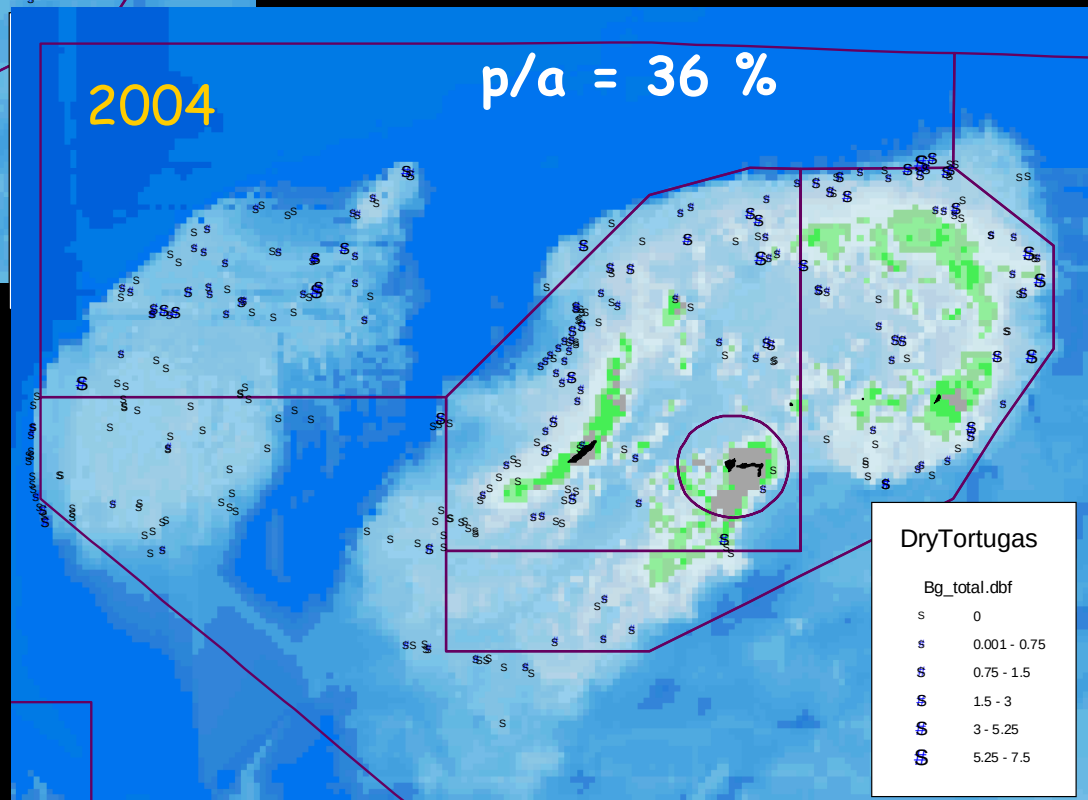
p/a = 18 %

TER North



2004

p/a = 36 %



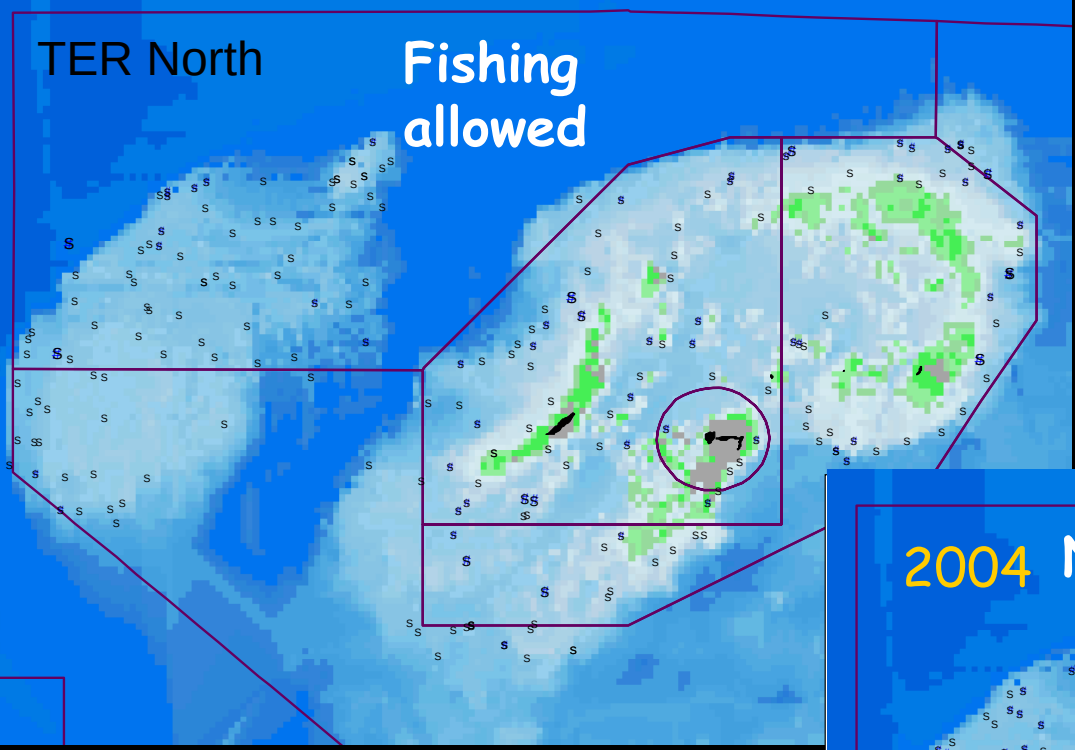
Increase in presence / absence (p/a) ratio of fish in TER

Ault et al., 2007

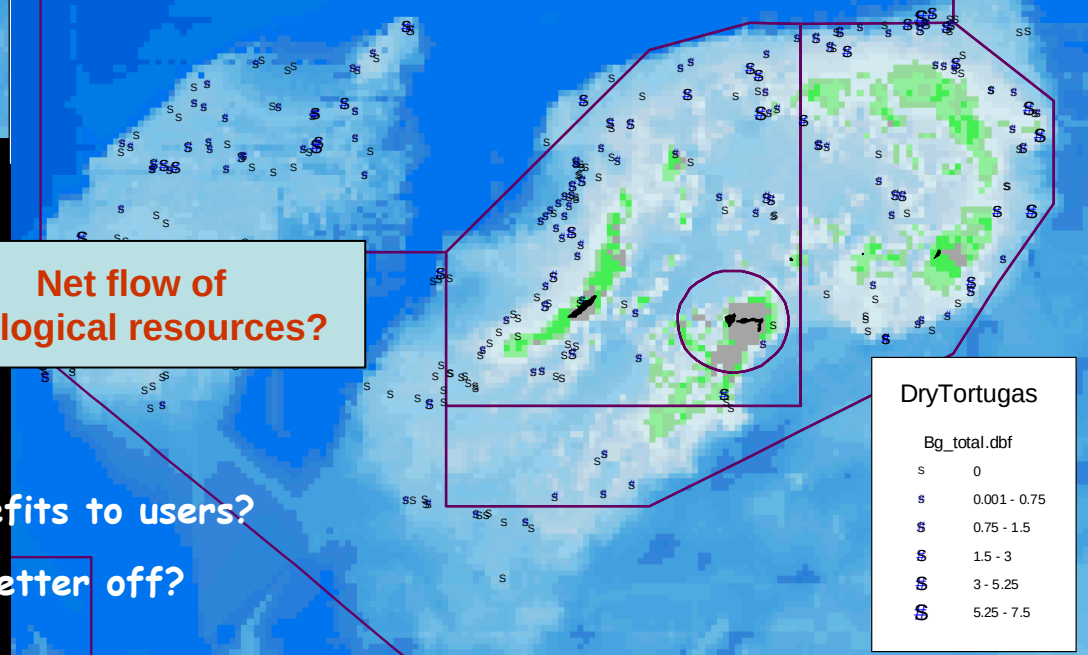
NCCOS

Before 2000

TER North



2004 No fishing Displaced fishers



Effect of TER on Humans?

Net flow of biological resources?

Decrease or increase in socioeconomic benefits to users?

User perceptions: are they worse off or better off?

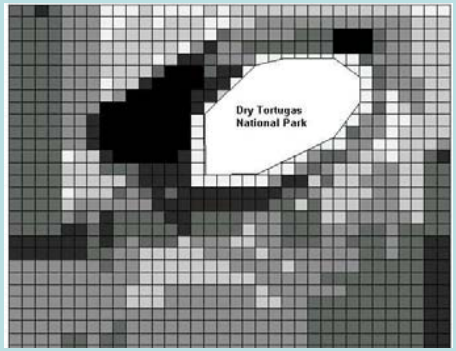
Objective #4 of 4

- Human Dimensions:
  - Collate/synthesize previous and ongoing socioeconomic research
    - Recreational fisheries
    - Commercial fisheries

- Determine change in patterns of resource use and extraction by humans caused by the TER implementation

Spatial shift in reef fish catch

Before closure (1998)



0
1 - 90
91 - 180
181 - 350
351 - 640
640 - 1,500

Cape Sable

TER North

29,0

29,33

DTNP

0,0

0,33

TER South

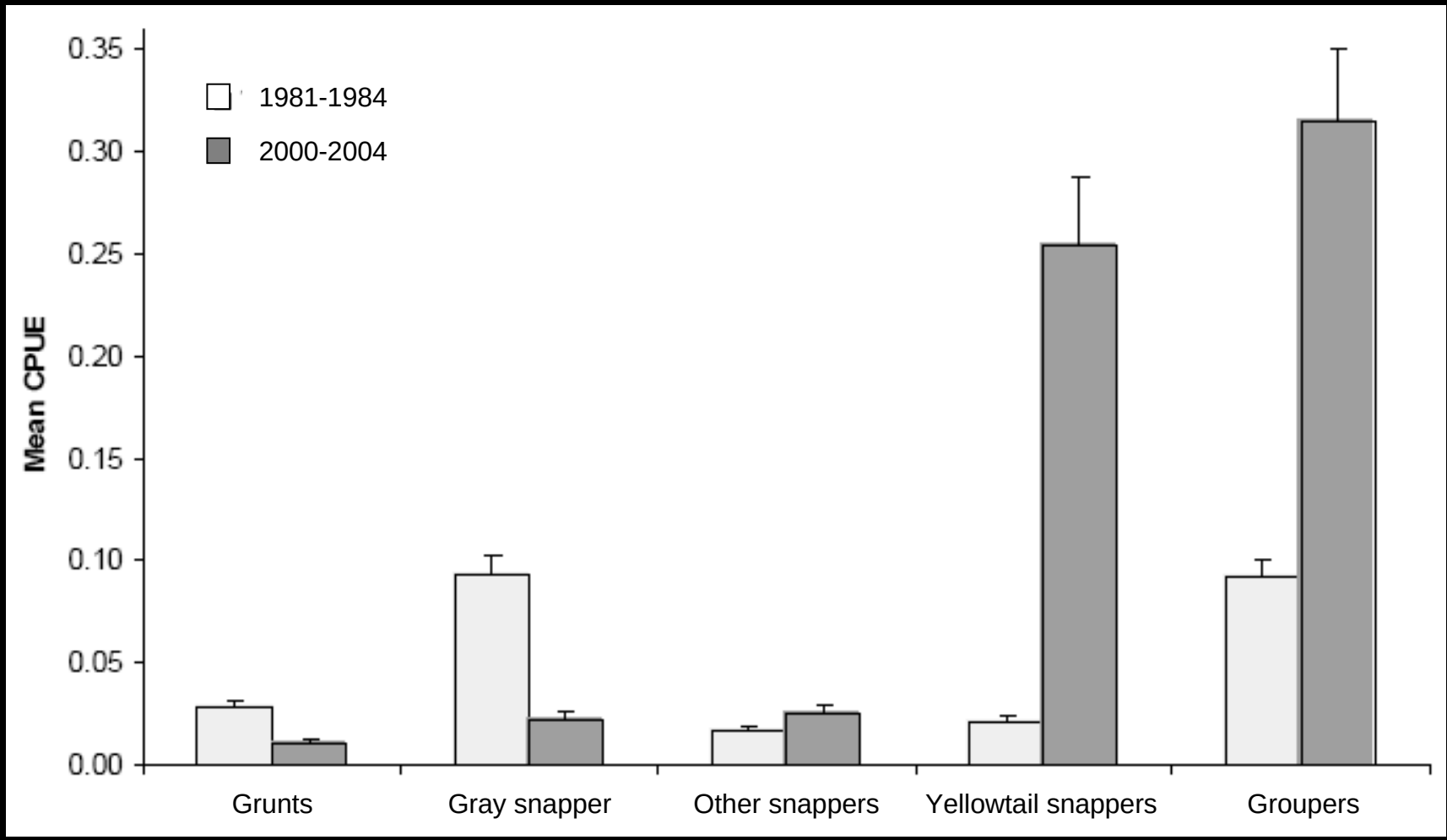
Key West

South Atlantic Ocean

After closure (2004)

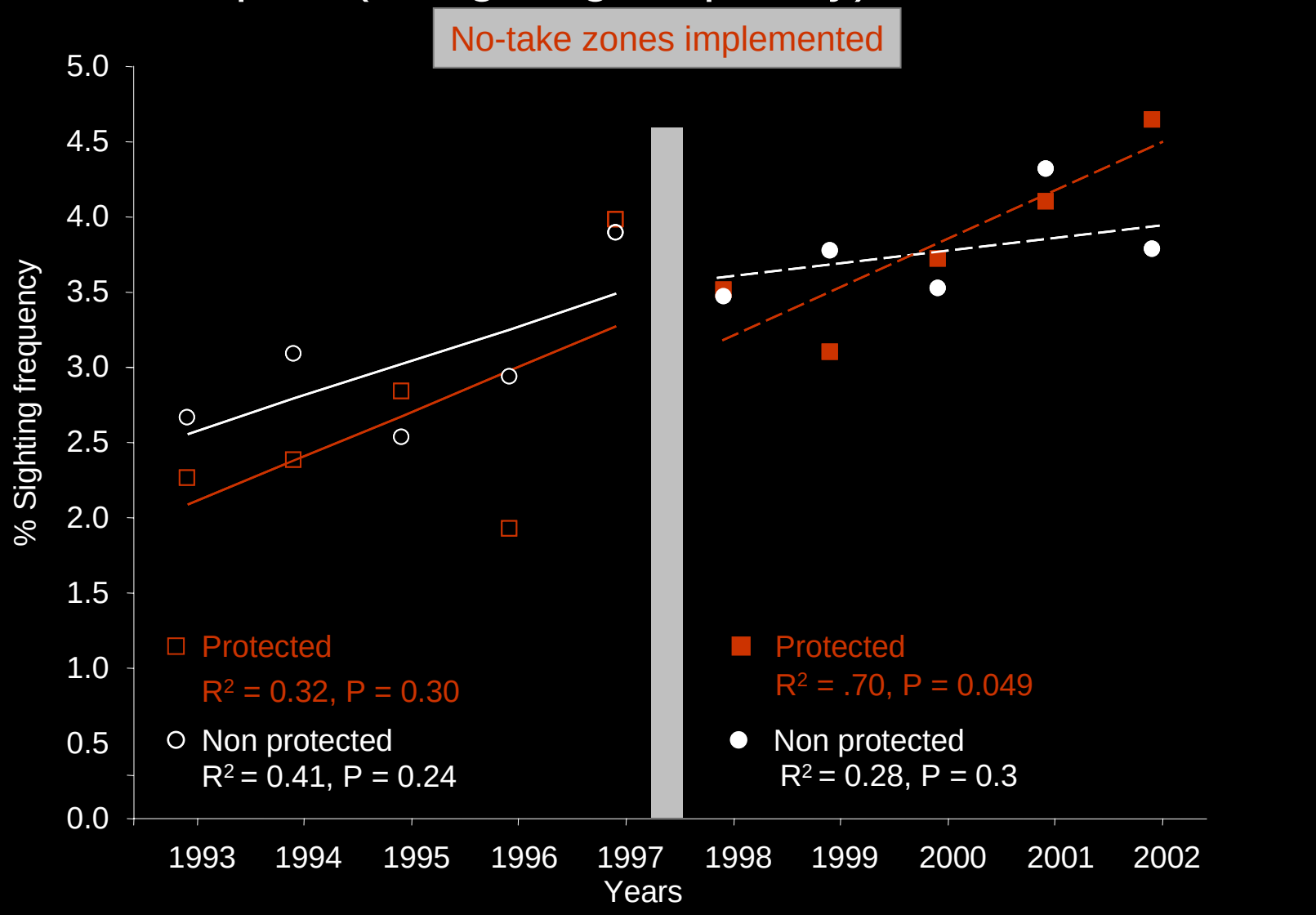
Thomas and Associates inc. (2007)

DRTO Creel census estimates



Ault et al., 2007

Groupers (% sighting frequency) in the FKNMS



Source Jeffrey (2004)

Are Tortugas MPAs effective?

- Analyses from the Tortugas Integrated Assessment suggest that short-term benefits have already begun to accrue from MPAs in Tortugas

- Effects of TER are confounded by existing regulations that also reduced exploitation (fishing pressure) of fishery resources in the region

- No negative impacts have been observed on the fishery to date

Assessing ecological condition of natural resources:

the case of corals in the DRTO

Resource management objectives (DRTO)

- To protect and interpret a pristine subtropical marine ecosystem, including an **intact coral reef community**.
- To protect populations of fish and wildlife (sea turtles; seabirds and other migratory bird species)
- To protect the pristine natural environment of the Dry Tortugas group of islands.
- Provide opportunities for scientific research in order t achieve goals 1 through 5

DRTO Final General Management Plan Amendment / Environmental Impact Statement

Baseline assessment needed…

- To determine current status of the resource.

- To determine stressors or threats affecting key ecosystem components
- Synthesize existing information and / or collect new data
- Determine appropriate management action:
  - If pristine, protect;
  - If degraded, restore if possible, and then protect
- Being done in consultation with the NPS SFCN Vital Signs process and local park biologists

Natural Resources Being Assessed…

- Reef fishes
- Lobsters,
- Sea urchins
- Benthic communities
  - Stony corals, octocorals, seagrass beds, Sponges etc.
- Water quality
- Geology
- Marine wildlife
  - Turtles, seabirds

Structural ecosystems components are degraded…

Agents of degradation:
- storms
- diseases
- overexploitation

Caribbean wide (1977-2001):

Absolute coral cover: 50% ↓ 10%

(Gardner *et al.* 2001)

U.S. Caribbean (2001-2004):

%cover per m² (N = 4190 quadrats, 838 sites)

algae: 43.9 ± 0.15

coral: 3.6 ± 0.09

(C. Jeffrey *et al.*, NOAA, unpublished data)

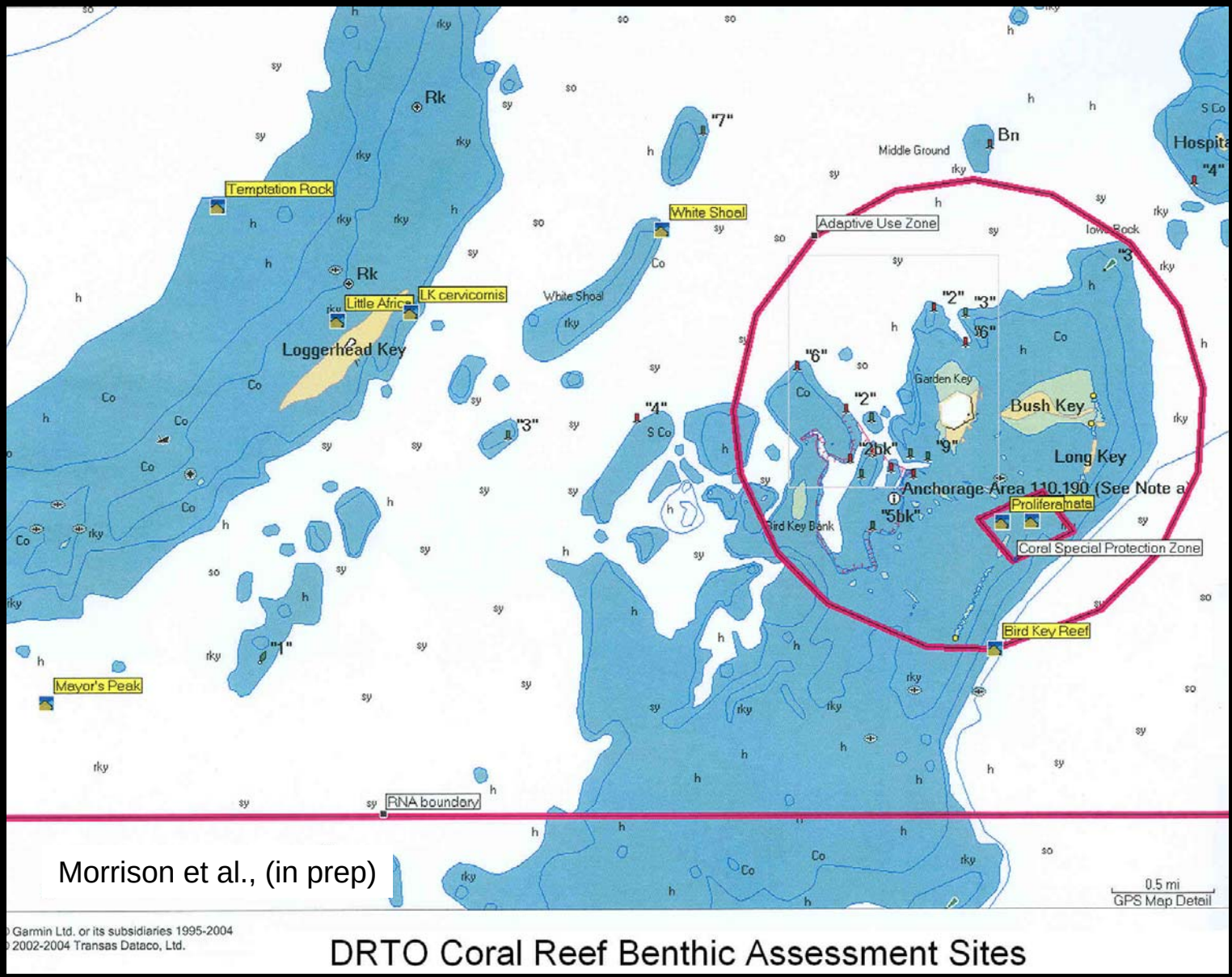
Sources of information

- DRTO has a long history of research…
  - Reefs first mapped in 1881 by Agassiz
  - Carnegie Institute's Tropical marine Research station (1904 – 1939)
    - Taxonomy of reef organisms (corals, sponges, fishes) and reef geology
- But, few long time series data on coral abundance, distribution, or demographics…
  - Longest time series on coral is from 1999 to present;
  - Methods vary among management and research programs
- Data are from fixed permanent stations (not probabilistic)…
  - CREMP has 7 permanent stations
  - NOAA CCFHR monitors at 30 stations; time series begin from 2000
  - NPS SFCN will monitor 40 sites in DRTO beginning 2008

Sources of information

- Data from probabilistic (random) sampling:
  - Accounts for spatial variability caused by patchy distribution of resources
  - Minimizes bias in domain-wide estimates
  - More representative of ecosystem processes, which are scale-dependent (in time & space)
- Data from fixed permanent sites:
  - Useful for detecting trends or rates of change;
    - trend must be tested for spatial and temporal consistency
  - Can’t be scaled up for domain (ecosystem) analyses

MAP of FWRI CREMP Sites



Morrison et al., (in prep)

DRTO Coral Reef Benthic Assessment Sites

FWRI CREMP Sites

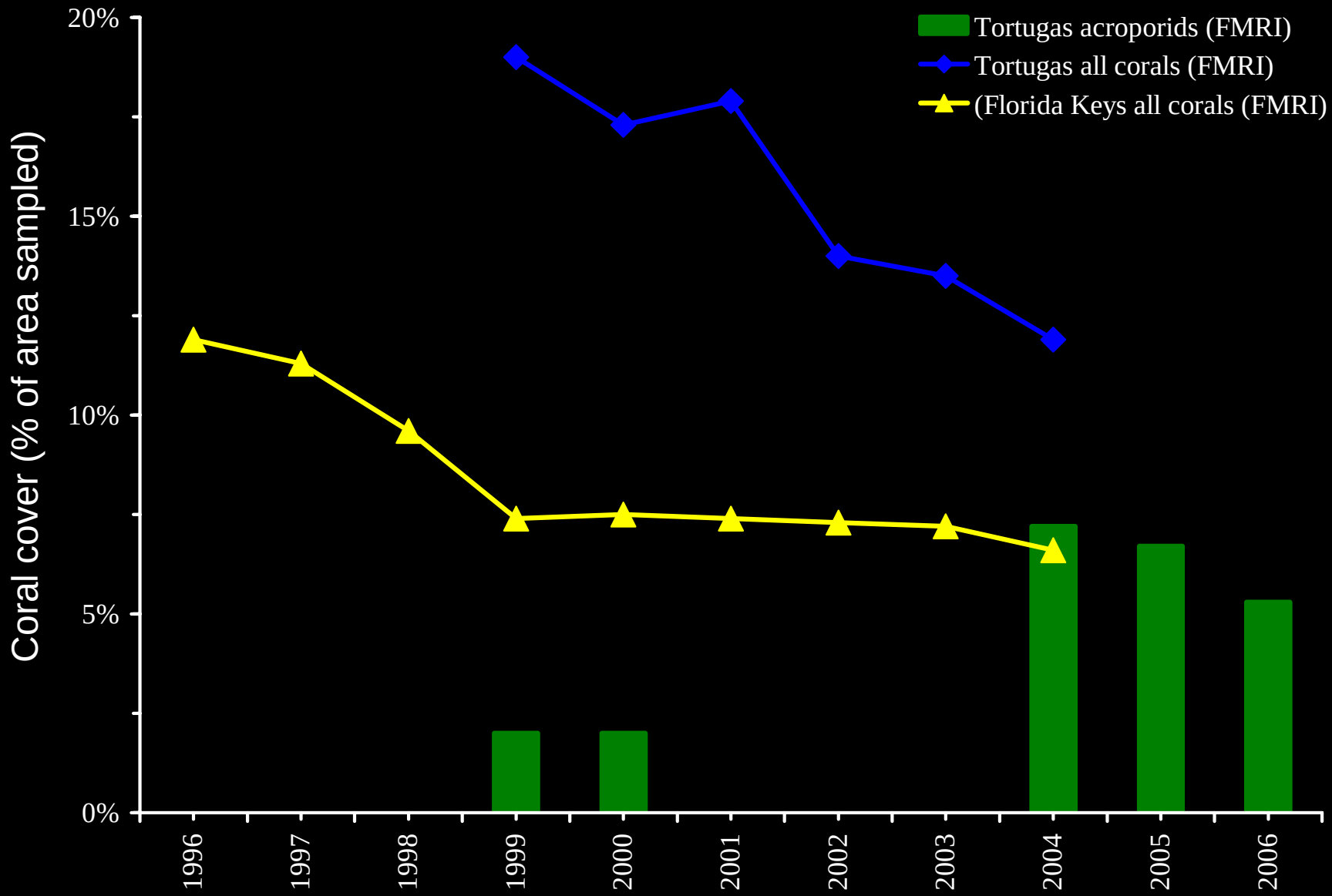
Coral Reef Type	Site Location	Rationale/Description
Bank reef with spur and groove	Bird Key Reef	Representative of the typical reef type on the outer edge of the Florida Keys reef tract. Monitored periodically since 1975; annually since 1999. Nearly on RNA-HUA boundary; perhaps outside the RNA.
Sloping bank reef (w/o spur and groove)	White Shoal	Representative of staghorn dominated coral communities that were once common in DRTO, but now rare due to die-off. ESA threatened species. Monitored periodically since 1989; annually since 1999. In the RNA.
Acropora palmata (elkhorn coral) dominated patch reef	Coral Special Protection Zone; 5 Foot Channel	Only remaining elkhorn coral population in DRTO. Primary reef former. ESA threatened species. Monitored annually since 2004.
Acropora prolifera dominated patch reef	Coral Special Protection Zone; 5 Foot Channel	Rare species in Florida. Largest known population, and likely only reef, in Florida. Only known population in Tortugas. Decimated by disease in 2003. Monitored annually since 2004.
Pinnacle rock reef	Temptation Rock and Mayer's Peak (two sites)	Representative of a common, characteristic Dry Tortugas reef type which is rare elsewhere in the Florida Keys. Within RNA. Monitored annually since 2004.
*Acropora cervicornis (*staghorn coral) dominated patch reef	Adjacent to Loggerhead Key	Hurricane damage assessment and recovery site. Representative of staghorn dominated coral communities that were once common in DRTO, but now rare due to die-off. ESA threatened species. Within RNA. Monitored annually since 2004.
Montastrea annularis dominated shallow patch reef	Little Africa area, adjacent to Loggerhead Key	Representative of a common DRTO reef type. Within RNA. Monitored annually since 2005.
Octocoral (soft coral) community.	Mayer's Peak	Representative of a common DRTO reef community type. Within RNA. Monitored annually since 2005.

Stressors and threats

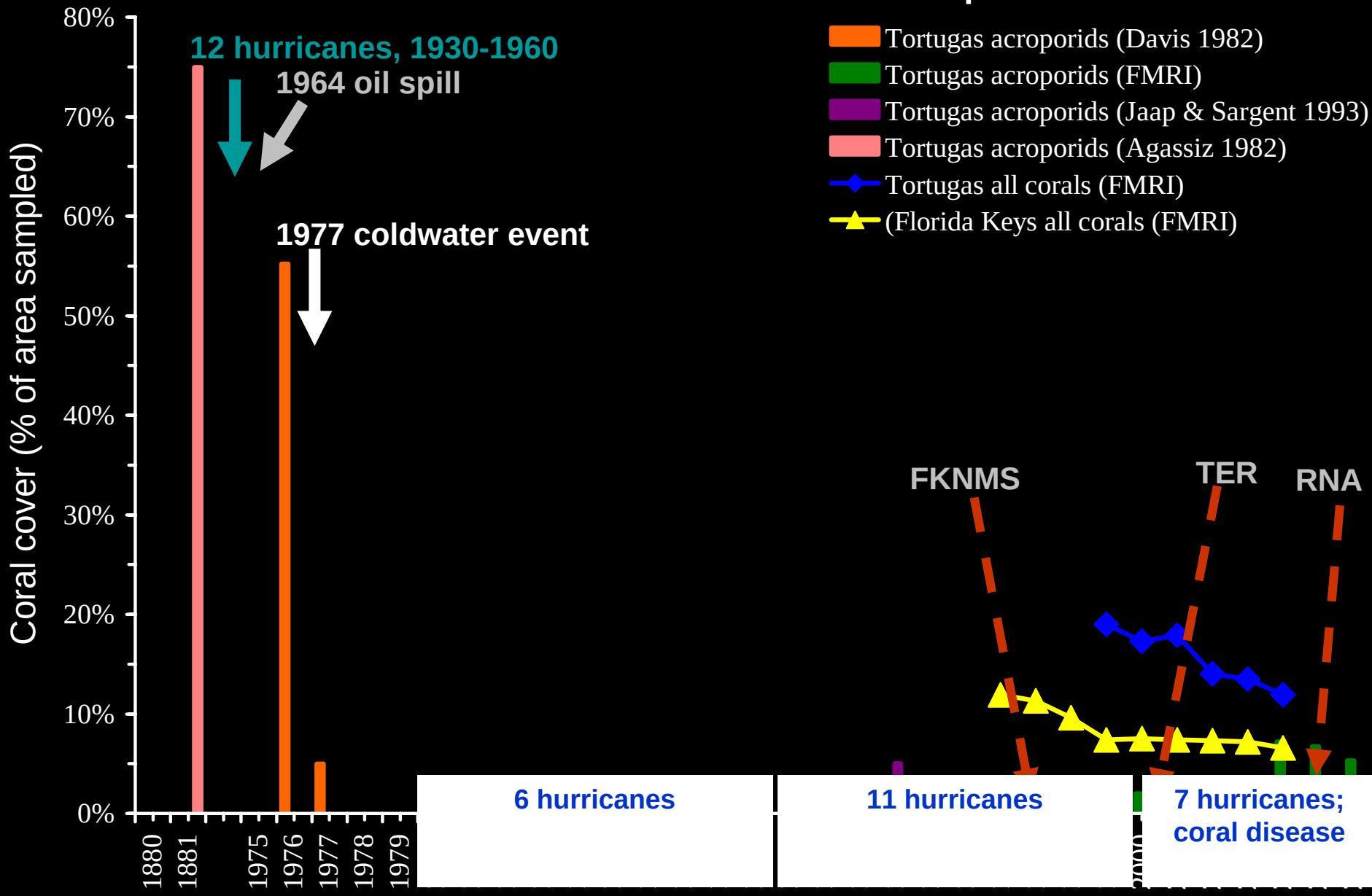
Stressor	Threat	South Florida & Florida Keys	Tortugas Region	DRTO	
Climate change	Increased sea surface temperature	X	O	Y	Global
	Sea level rise	X	O	Y	
	Ocean acidification	X	O	Y	
Extreme events	Tropical storms	X	O	Y	
	Coral disease epidemics	X	O	Y	
Invasive species	Non native species introductions	X	O	Y	Local
Resource extraction	Fishing	X	O		
	Trade in live species	X	O		
	Habitat destruction	X	O		
	Boat groundings & anchor damage	X	O		
Pollution	Sedimentation	X			
	Eutrophication (nutrient enrichment)	X			
	Marine debris & derelict fishing gear	X			
	Chemical contaminants	X			
	Fossil fuel exploration; oil spills				

Waddell 2005; Wilkinson et al, 2006

Demise of corals: 1996- to present



Demise of corals: 1881 to present



Summary

- Coral resources at long-term permanent sites in the Tortugas region are degraded when compared with historical data.
  - Trends are consistent with observed declines in coral reefs in the Florida Keys and the Wider Caribbean.
- Likely causes are global stressors such as elevated sea surface temperature, extreme events, and coral disease.
  - Localized management efforts will do vey little to alleviate global stressors.
- A park-wide characterization of coral resources is needed to determine the condition of areas that are not currently being monitored.
  - Are there other areas of the park where coral resources are in better condition than those being monitored?
  - Are there areas where coral recruitment is occurring or with higher potential for recruitment?

Recommendations

- Develop a targeted monitoring program for corals based on probabilistic sampling.
  - Provides more information on spatial distribution of patchy resources such as corals;
  - Provides data that can be used to characterize the entire ecosystem rather than one of its components;
  - Takes into account ecosystem processes that are scale dependent (i.e. vary at different spatial and temporal scales;
  - Potential to identify new hot spots for natural resources;
- Better collaboration among research agencies is needed.
  - To collect complementary data that would be useful for management
  - Exchange of information and data helps prevent duplication of effort
- Better management of data and information
  - E.g., greater reporting and centralized warehousing of data at the Park is needed